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A probable cell model in the creation of dream scenarios

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Abstract

In rapid eye movement (REM) period of sleep, the discharges sent by the pontine reticular formation, stimulating the neuron's pools of the memories in the neocortex and other memory storage areas of the brain, constitute the dream scenarios. If the neuronal connections of memories establish random synaptic relationships with each other, it can be concluded that recently-activated neurons can randomly stimulate the neurons of other memories converging on them. For example increasing activities in the memory neurons belonged to Grandmother and an unrelated war scene may constitute a dream scenario by random connections as a 'grandmother with weapon' without subject integrity.

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1. Introduction

The brainstem not only generates the rapid eye movement (REM) period of sleep, but also enables dreaming. In the REM phase, sensory inputs and motor stimulus in the brain ceases and the prefrontal cortex are stimulated only by the brainstem. So perception turns to the internal domain or endogenous cerebral activity while sleeping (Pareja et al., 2000). Pontine reticular formation is involved in the cholinergic initiation and/or maintenance desynchronized sleep and midbrain reticular formation mediates arousal (Villablanca et al., 2001). However, the mechanisms responsible for the generation of the dream scenario still remained largely unknown.

Sigmund Freud started the dream interpretation as a scientific research and used it in the psychoanalysis in the end of 19th Century. Freud claimed that dreams were an unconscious way for us to express our disguised wish fulfillment and aggressive fantasies, which are forbidden while we are awake (Bear et al., 2007). Another famous dream theorist Carl Gustav Jung, influencing from theology and metaphysics, proposed that, collective unconscious and religious faith influences our contents of dreams (Solomon, 2003). Recently the most generally accepted dream theory has been offered by Hobson and McCarley, which named "activation-synthesis hypothesis (Coolidge, 2006). According to this hypothesis, dreams are the result of the forebrain responding to random activity initiated at the brainstem. This activity is demonstrated by the ponto-geniculo-occipital (PGO) waves that occur during REM sleep (Franklin et al., 2005). The triggering neurons of the pontine PGO wave generator are located within the caudolateral peribrachial and the locus subceruleus areas. The transferring neurons of the pontine PGO generator are located within the cholinergic neurons of the laterodorsal tegmentum and the pedunculopontine tegmentum. The

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triggering and transferring neurons of the pontine PGO wave generator are modulated by aminergic, cholinergic, nitroxergic, GABA-ergic, and glycinergic cells of the brainstem (Datta, 1997).

Since PGO-generating cells project to the entorhinal cortex, piriform cortex, amygdala and hippocampus, these structures could also be involved in the modulation of cognitive functions (Datta et al., 1998). According to REM-sleep specific neuronal activation-dependent consolidation theory, during wakefulness external information makes a temporary impression in the neocortex and is processed in specific forms in the amygdala, hippocampus and parahippocampal areas. During the REM sleep, with PGO waves, the amygdala, hippocampus and parahippocampal area are also activated to organize and consolidate these random information acquired during wakefulness (Datta, 2006). So REM sleep constitutes a way for hippocampus-driven cortical activation, which may play a role in the communication of memory traces from the hippocampus to the cerebral cortex (Ribeiro et al., 2002).

The amygdala, hippocampus, thalamus, hypothalamus, orbitofrontal cortex and anterior cingulate make up the limbic system which is often referred to as the emotional brain. Since the amygdaloid complexes are known to associate an affective content to perception (Malenka et al., 2004), it can be speculated that the activation of amygdala and anterior cingulate cortex could account for the emotional aspects of dreaming (Maquet et al., 1997; Wheeler et al., 2007).

2. Neuronal Relationships in the Memory Pools, Probable Mechanism in Formation of Dream Scenarios

Persistent neural activity causes to develop an engram between the related neurons in the memory pools (Yin, 1999). So, memories come into being with strengthen synaptic connectivity (Lynch, 2004) by long term potentiation (LTP) mechanism (Kandel et al., 1991). With new protein synthesis by LTP, new axonal branches, neurotransmitters, synaptic buttons on the presynaptic terminals and new receptor synthesis on the postsynaptic cells can be developed. An increase in the number of presynaptic axons lowers the membrane potential difference by increasing the excitatory post synaptic potentials (EPSP) on the postsynaptic neurons. These hypopolarized neurons (in the 'sub-luminal fringe) may easily create an action potential by a new facilitating stimulus from other relationships. In considering the axon of each neuron in the central nervous system is divided into thousands of axon branches on average (Ganong, 2010); it can easily be supposed that some of these axon terminals establish thousands of random synaptic relationships within the related neuronal memory pool.

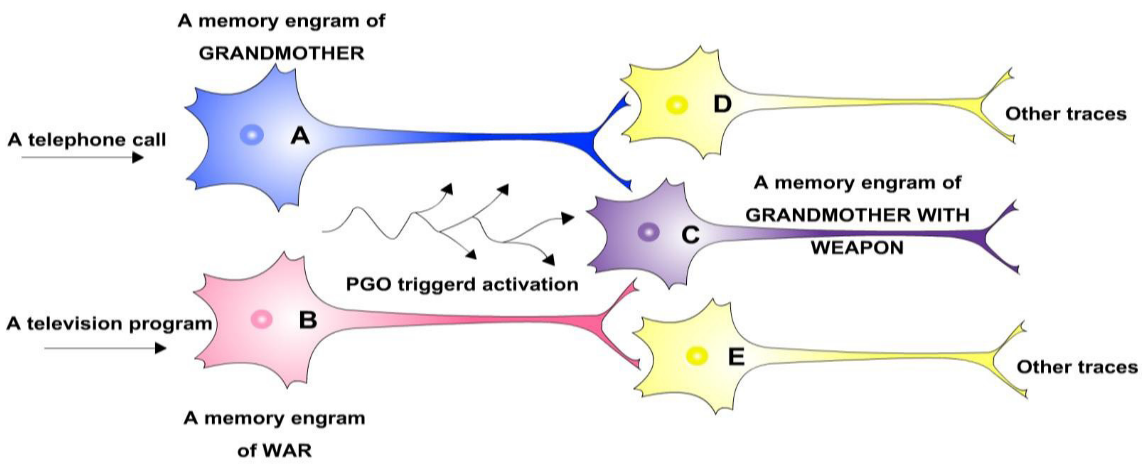

Figure 1. A neuronal net in the memory storage area. Excitability of A neurons increased due to a telephone call. Excitability of B neurons increased by watching television. Components of memories A, B and C create the dream scenario.

In our hypothetical nerve net inspired from Ganong's "simple nerve net figure" (figure 1) (Ganong, 2010); some of the axonal branches belonging to memory A and memory B converge on memory C, and some of the axonal branches belonging to memory B diverges on memory C and memory E. These can be regarded as unrelated memories. The activation of A or B will set up EPSPs in C. If A and B are stimulated and generate action potentials at the same time, due to summation of EPSPs in C, membrane potential may well reach the firing level of C. Thus the effect of the depolarization caused by the impulse in A is facilitated by the activity in B, and vice versa. In this case E has not fired, but its excitability has been increased, and it is easier for activity in neuron E to fire if there is EPSP coming from other neurons. Thus, neurons belonging to different and independent memory components can influence each other's activity and can activate each other because of their random connectivity in a memory pool.

In our opinion the memory neurons related to the people or events or subjects that have been dominated or remembered in recent waking activities, dropping their threshold, can be stimulated simultaneously. In the case of random axonal establishment and facilitating each other's activation, these neurons representing the memory pieces, become the components of a dream scenario independent from the subject integrity. For instance, a person who dreams of her/his grandmother fighting in military uniform with a weapon has probably received effective sensory inputs about some components of this scenario during the day. Moreover, she/he has somehow activated the neuronal cycle constituting this information. For example, that person may have been influenced by recently viewing a war scene on TV; by receiving a call from her/his grandmother at the same time. If the neuronal components of these recently-stimulated memories (grandmother and war) establish random synaptic relationships with each other, it can be concluded that activated neurons can randomly stimulate the neurons of other memories, or at least, facilitate the stimulation of these neurons. Thus, one can dream absurd scenarios (the grandmother with gun) which are based on known objects or sounds remembered in those days. Crick and Mitchison proposed a 'neural network and REM sleep' theory in 1980s. They asserted that, 'if the stored memories share common features, random stimulation often produces mixed outputs' (Crick et al., 1995).

Studies reveal that people who are born blind do not dream visual images; rather, they experience dreams based on audio memory. The implication is that people cannot visually dream of an object/person/event which they have never seen before. People only dream of the information obtained in daily life and retained in the brain as a memory (Kerr et al., 2004).

3. Conclusion

Although there are too many studies implying that dream scenarios appear by the random relationships between the neurons of memories; there is no definitely description about the mechanism of how or why these cells are contributing to create a dream scenario? We propose that the random connections between the neurons of memories can easily be activated by increased excitability of the neurons, due to the subject's exposed to an effective impulses in its daily life, and may constitute the dream scenario of that day.

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